(12) UK Patent Application (19) GB (11) 2 327 525 (13) A

(43) Date of A Publication 27.01.1999

(21) Application No 9809623.3

(22) Date of Filing 07.05.1998

(30) Priority Data
(31) 97034111 (32) 21.07.1997 (33) KR

(51) INT CL^6
G11B 7/24

(52) UK CL (Edition Q)
G5R RB21 RB265

(56) Documents Cited
GB 2017379 A EP 0762406 A1 EP 0745985 A2
EP 0520619 A1 EP 0368442 A2 WO 98/00842 A1
WO 97/14145 A1 WO 97/09716 A1

(58) Field of Search
UK CL (Edition P) G5R RB21 RB24A
INT CL^6 G11B 7/007 7/14 7/24
Online: WPI

(71) Applicant(s)
Samsung Electronics Co Limited
(Incorporated in the Republic of Korea)
416 Maetan-dong, Paldal-gu, Suwon-city,
Kyungki-do, Republic of Korea

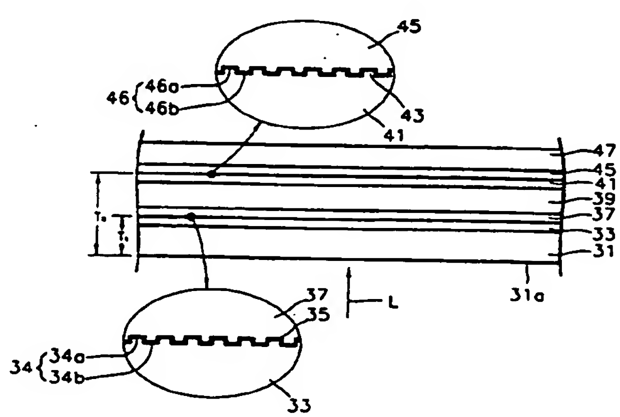
(72) Inventor(s)
Myoung-June Kim
Seong-sue Kim
Young-man Ahn
Myong-do Ro
Du-seop Yoon
Seung-tae Jung
Jang-hoon Yoo
Chul-Woo Lee
Hea-jung Suh

(74) Agent and/or Address for Service
Appleyard Lees
15 Clare Road, HALIFAX, West Yorkshire, HX1 2HY,
United Kingdom

(54) Abstract Title
Optical disk

(57) An optical disk that can be compatibly reproduced by optical disk players of different format standards includes, in sequence from the side illuminated by light (L), a transparent substrate (31) transmitting incident light, a first recording layer (33) having an information recording surface (34) on which an information signal is recorded and in which recorded information thereon is reproduced by light of a first wavelength (e.g. 650nm), a partially light-transmitting film (35) formed on one surface of the first recording layer, exhibiting different transmittances depending on the wavelength of the incident light and therefore reflecting most of the light of the first wavelength and transmitting most of the light of a second wavelength, (e.g. 780nm) a spacing layer (39) transmitting the light transmitted through the partially light-transmitting film, a second recording layer (45) having an information recording surface on which an information signal is recorded and in which recorded information thereon is reproduced by the light of the second wavelength transmitted through the partially light-transmitting film, and a reflective film (43) formed on the information recording surface of the second recording layer and reflecting the light focused on the second recording layer.

FIG. 2



GB 2 327 525 A

FIG. 1

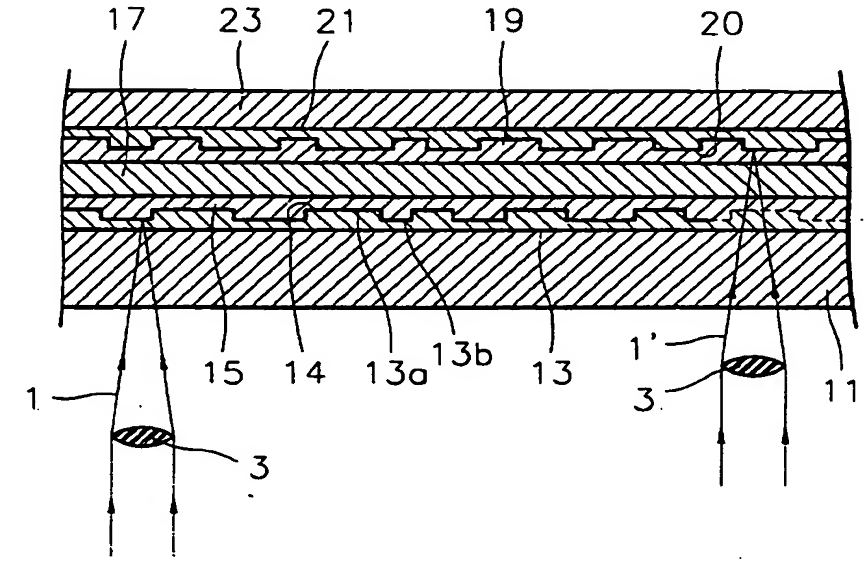

17
23
21
19
20
15
14
13a
13b
13
1'
3
11
1
3

FIG. 2

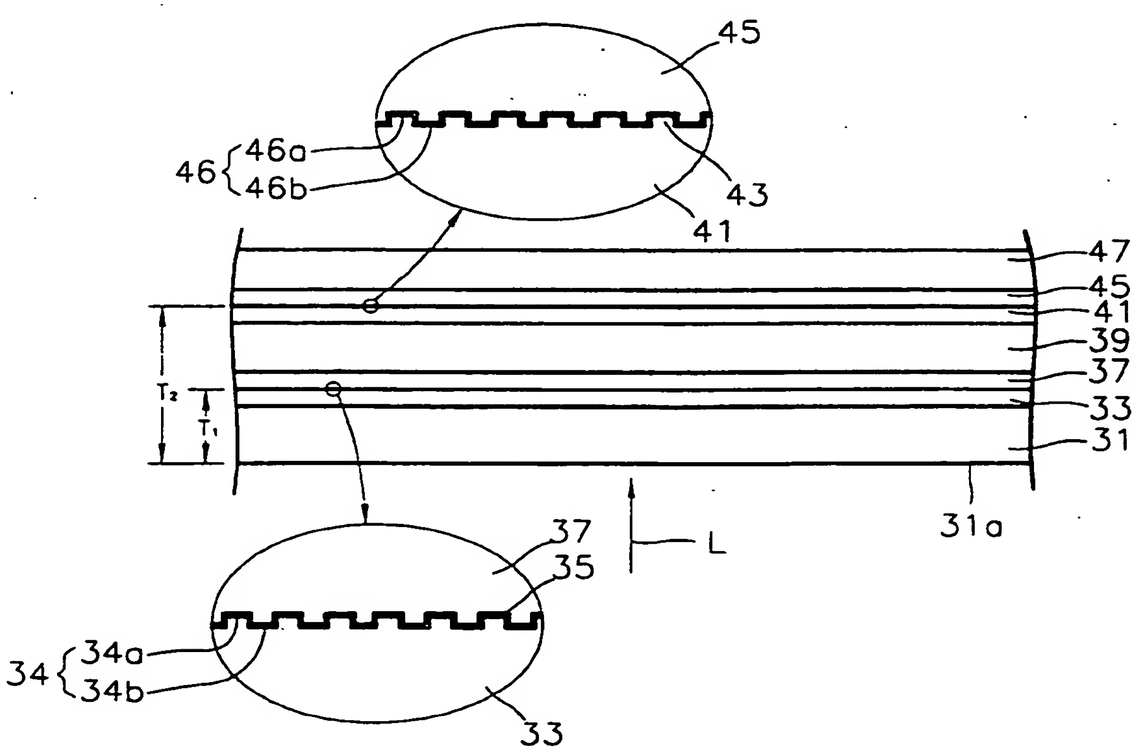

45
46
46a
46b
43
41
47
45
41
39
37
33
31
T2
T1
31a
L
37
35
34
34a
34b
33

FIG. 3

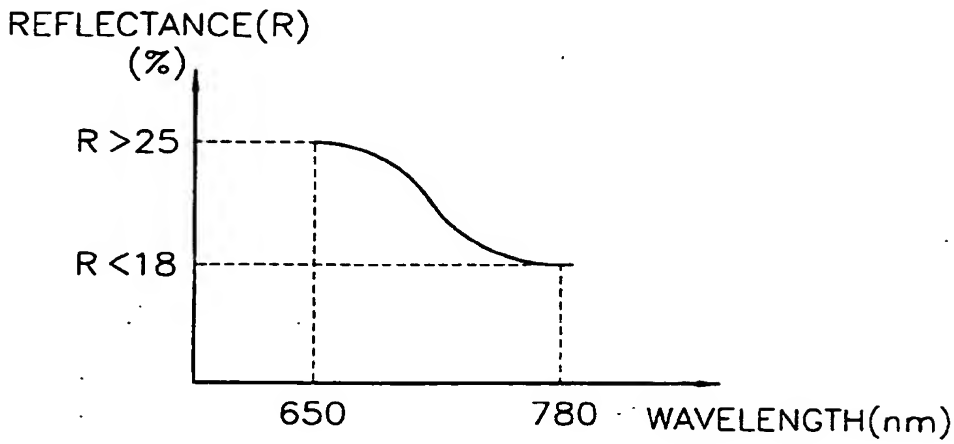

REFLECTANCE(R)
(%)
R >25
R <18
650
780
WAVELENGTH(nm)

FIG. 4

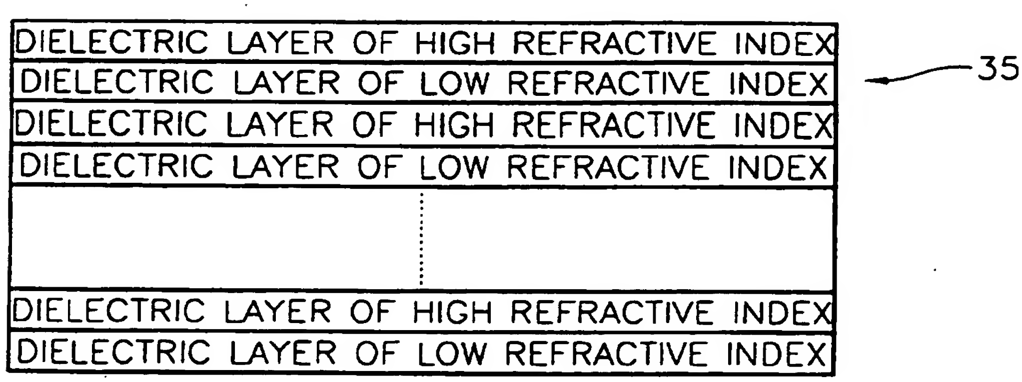

DIELECTRIC LAYER OF HIGH REFRACTIVE INDEX
DIELECTRIC LAYER OF LOW REFRACTIVE INDEX
DIELECTRIC LAYER OF HIGH REFRACTIVE INDEX
DIELECTRIC LAYER OF LOW REFRACTIVE INDEX
DIELECTRIC LAYER OF HIGH REFRACTIVE INDEX
DIELECTRIC LAYER OF LOW REFRACTIVE INDEX
35

FIG. 5

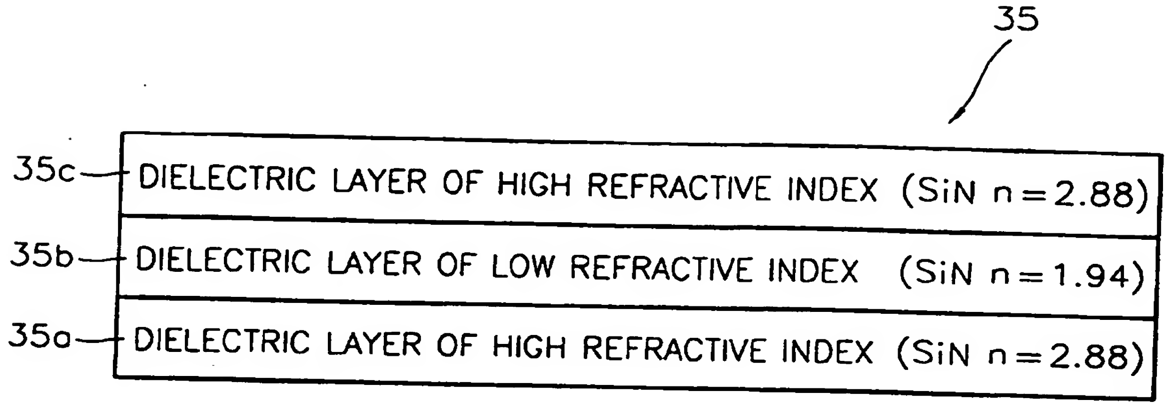

35
35c
DIELECTRIC LAYER OF HIGH REFRACTIVE INDEX (SiN n=2.88)
35b
DIELECTRIC LAYER OF LOW REFRACTIVE INDEX (SiN n=1.94)
35a
DIELECTRIC LAYER OF HIGH REFRACTIVE INDEX (SiN n=2.88)

FIG. 6

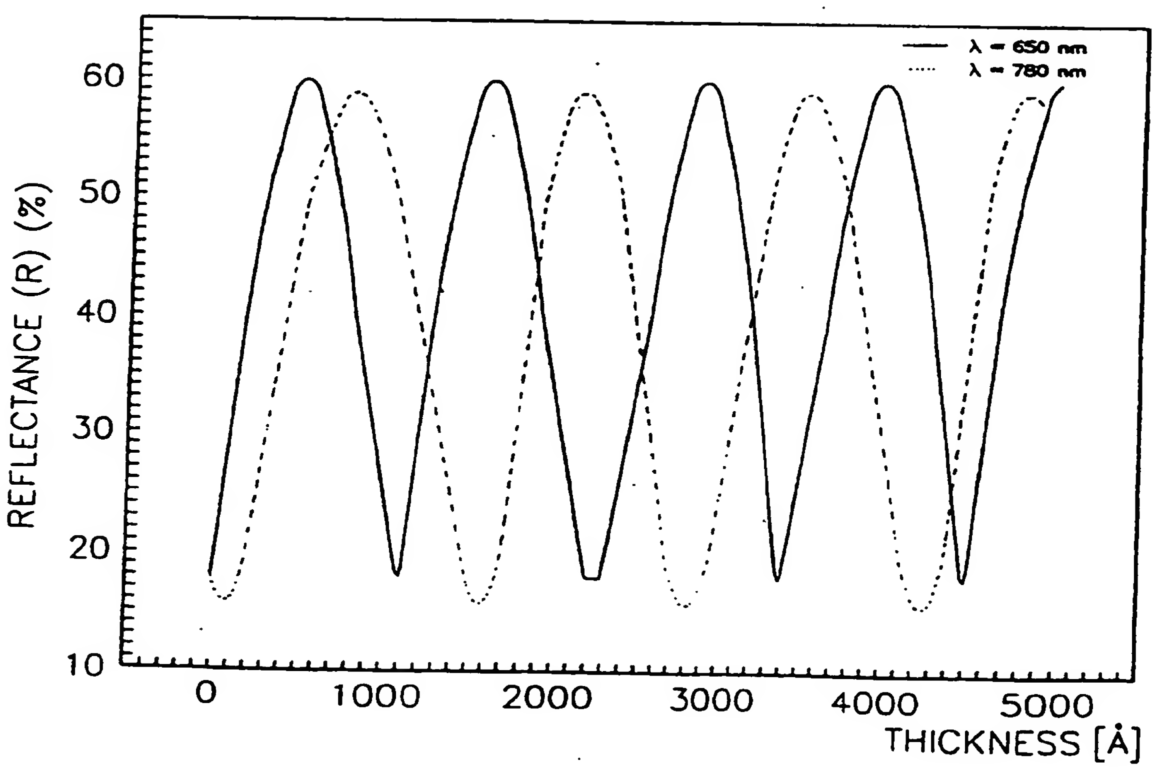

λ = 650 nm
λ = 780 nm
REFLECTANCE (R) (%)
60
50
40
30
20
10
0
1000
2000
3000
4000
5000
THICKNESS [Å]

FIG. 7

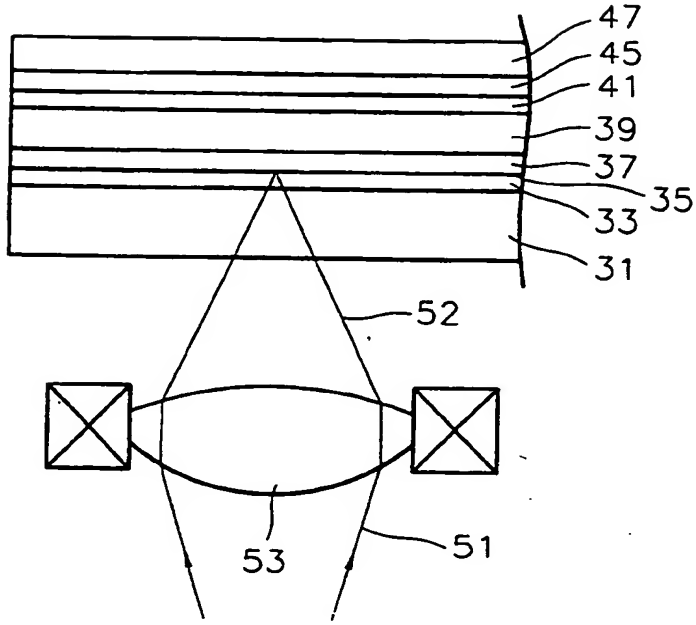
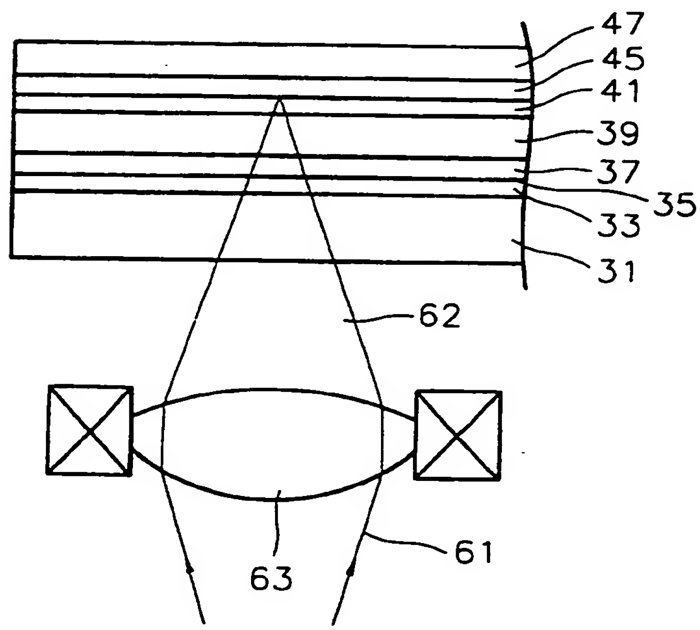


FIG. 8



2327525

OPTICAL DISK

The present invention relates to an optical disk having two or more information recording layers, and more particularly, to an optical disk that can be compatibly reproduced by optical disk players of different format standards.

Generally, optical disks are made to have multi-layers including two or more information recording layers as a method of increasing the information recording capacity of one optical disk.

An example of a conventional dual layer optical disk is explained with reference to FIG. 1. As shown in FIG. 1, the optical disk comprises, in sequence from the side illuminated by light, a first transparent substrate 11, a first recording layer 13 having an information recording surface, a first adhesive layer 15, a spacing layer 17, a second adhesive layer 19, a second recording layer 21, and a second transparent substrate 23.

The first substrate 11 is made of a 1 mm thick transparent PVC, and transmits incident light. The first recording layer 13 is made of an ultraviolet curable resin, and is formed on one surface of the first substrate 11. Lands 13a and grooves 13b which form a spiral track are provided on the first recording layer 13. A partially light-transmitting film is formed on the surface 14 of the first recording layer 13 adjacent to the first adhesive layer 15 to transmit some of the incident light. The preferred material of the partially light-transmitting film is material such as zinc selenide (ZnSe), bismuth oxide (BiO), cadmium sulphide (CdS), cadmium telluride (CdTe) or silicon carbide (SiC).

In addition, the second recording layer 21 has a similar configuration to that of the first recording layer 13, and the surface 20 adjacent to the second adhesive layer 19 is provided with a reflective layer which has a reflectance of approximately 90%. The first and second adhesive layers 15 and 19 and the spacing layer 17 are layers for bonding and spacing between the first recording layer 13 and the second recording layer 21 and transmit the incident light. The second substrate 23 which is made of transparent PVC protects the second recording layer 21.

In the optical disk constructed as described above, the reproducing of the recorded information is carried out by utilizing the incident beam which enters from the first substrate 11 and is focused by an objective lens 3. That is, the information recorded on the first recording layer 13 can be reproduced by adjusting the objective lens 3 to focus a beam 1 on the first recording layer 13, and the information recorded on the second recording layer 21 can be reproduced by adjusting the objective lens 3 to focus a beam 1 on the second recording layer 21.

Though the optical disk constructed as described above, has the advantage of increasing the recording capacity by having dual layers of first and second recording layers 13 and 21, it can only be used by an optical disk player utilizing a 650 nm wavelength light, for instance, a digital versatile disk read only memory (DVD-ROM) player.

On the other hand, recently in the art of the optical disk player, the digital versatile disk player according to a new standard is commercially available, which is able to realize high quality of sound and images, with increased recording capacity. The digital versatile disk

player employs a laser emitting a 650 nm wavelength light as the light source while in the compact disk player the wavelength of the laser light is 780 nm, and the standard numerical aperture of the objective lens is 0.6. In addition, in the specification of the digital versatile disk for the digital versatile disk player, a thickness of 0.6 mm between the incident surface and the recording surface and a track pitch of 0.74 μm are the standard while in the compact disk the thickness is 1.2 mm and the track pitch is 1.6 μm.

Since the above-mentioned digital versatile disk player is developed in various configurations to be able to compatibly reproduce a disk of the compact disk standard, the information recorded on a compact disk can also be reproduced by the digital versatile disk player.

However, information recorded on a digital versatile disk cannot be reproduced by a compact disk player because of the difference in the specifications.

With reference to the problems mentioned above, it is an aim of at least preferred embodiments of the present invention to provide an optical disk having two or more information recording layers, and being reproducible compatibly by optical disk players of different format standards.

Accordingly, to achieve the above objective, there is provided an optical disk capable of being reproduced by optical disk players of different format standards which includes a transparent substrate transmitting incident light, a first recording layer having an information recording surface on which an information signal is recorded. The recorded information of which is reproduced

by light of a first wavelength. Also, the optical disk includes a partially light-transmitting film formed on one surface of the first recording layer, exhibiting different transmittances depending on the wavelength of the incident light. Most light of the first wavelength are reflected by the partially light-transmitting film and most light of a second wavelength are transmitted. There is also a spacing layer transmitting the light transmitted through the partially light-transmitting film, a second recording layer having an information recording surface on which an information signal is recorded. The recorded information is reproduced by the light of the second wavelength transmitted through the partially light-transmitting film. Also, there is a reflective film formed on the information recording surface of the second recording layer which reflects light focused on the second recording layer.

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings, in which:

FIG. 1 is a section view illustrating an example of a conventional optical disk having dual layers;

FIG. 2 is a section view illustrating an embodiment of an optical disk according to the present invention;

FIG. 3 is a graph illustrating the reflectance-wavelength relationship of the partially light-transmitting film of an optical disk according to the present invention;

FIG. 4 is a section view illustrating an example of the partially light-transmitting film of an optical disk according to the present invention;

FIG. 5 is a section view illustrating another example of the partially light-transmitting film of an optical disk according to the present invention;

FIG. 6 is a graph illustrating the reflectances of light beams of first and second wavelengths according to variations the in thickness of the first dielectric layer of FIG. 5;

FIG. 7 is a section view of an optical disk according to the present invention schematically illustrating a mode of utilizing a first recording layer of the optical disk; and

FIG. 8 is a view of an optical disk according to the present invention schematically illustrating a mode of utilizing a first recording layer of the optical disk.

Referring to FIG. 2, an embodiment of an optical disk according to the present invention comprises, in sequence from the side illuminated by light (L), a transparent substrate 31, a first recording layer 33, a partially light-transmitting film 35, a spacing layer 39, a reflective film 43, a second recording layer 45, and a protective layer 47.

The transparent substrate 31 transmits incident light (L) and protects the first recording layer 33. The transparent substrate 31 is made of a polymeric material such as transparent PVC as in the conventional optical disk. The first recording layer 33 has an information

recording surface 34 on which information is recorded, and the information recorded on the information recording surface 34 is reproduced by incident light of a first wavelength. The first wavelength, in this case, is a wavelength of about 650 nm, and therefore the first recording layer 33 corresponds to the information recording layer of the conventional digital versatile disk. Lands 34a and pits 34b which form a spiral track are provided on the information recording surface 34 of the first recording layer 33. Here, the track pitch of the first recording layer 33 is approximately 0.74 μm, and the thickness (T_1) between a light entering surface 31a of the transparent substrate 31 and the information recording surface 34 of the first recording layer 33 is preferably 0.6 mm.

The partially light-transmitting film 35 is formed on the information recording surface 34 of the first recording layer 33 and exhibits different transmittances depending on the wavelength of the incident light, and therefore reflects most of the light of the first wavelength and transmits most of the light of a second wavelength of, for example, 780 nm for reproducing an information signal recorded on the second recording layer 45.

The spacing layer 39 is a layer for bonding and spacing between the first recording layer 33 and the second recording layer 45 and transmits the incident light of the second wavelength which has travelled through the partially light-transmitting film 35.

Here, adhesive layers 37 and 41 are formed between the partially light-transmitting film 35 and the spacing layer 39 and between the spacing layer 39 and the second

recording layer 45, respectively. The adhesive layers 37 and 41 are made of an ultraviolet curable resin and are formed by the well-known spin coating method.

The second recording layer 45 has an information recording surface 46, and the recorded information is reproduced by the light of the second wavelength transmitted through the partially light-transmitting film 35. The second recording layer corresponds to the information recording layer of the conventional compact disk (CD). The second recording layer 45 is provided with lands 46a and pits 46b which form a spiral track in a similar manner as the first recording layer 33. Here, the track pitch of the second recording layer 45 is about 1.6 μm and the thickness (T_2) between a light entering the surface 31a of the transparent substrate 31 and the information recording surface 46 of the second recording layer 45 is preferably 1.2 mm.

The information recorded on the first recording layers 33 may be substantially the same as the information on the second recording layer 45. For example, when the optical disk according to the present invention is used as a compatible audio disk, the first and second recording layers 33 and 45 are respectively recorded with the same audio information in different formats. That is to say, the first recording layer 33 is recorded with super-audio information having a sampling rate of 96 KHz or higher and 5.1 channels of Dolby AC3, and the second recording layer 45 is recorded with stereo audio information having a sampling rate of 44.1 KHz. Therefore, the optical disk is played either to produce stereo audio sound in a compact disk player or to produce super audio sound.

The reflective film 43 is formed between the adhesive layer 41 and the information surface 46 of the second recording layer 45, and reflects light focused on the second recording layer 45. The reflective film 43 is formed of a material such as aluminum, aluminum alloys, copper or copper alloys.

The protective layer 47 for protecting the second recording layer 45 is formed on the second recording layer 45 to prevent oxidation and damage to the second recording layer 45.

The partially light-transmitting film 35, is now explained in detail with reference to FIGS. 3 through 6.

As shown in FIG. 3, it is preferable that the partially light-transmitting film 35 has a reflectance of higher than about 25% with respect to a 650 nm wavelength, and a reflectance of lower than 18% with respect to a 780 nm wavelength.

It is for the purpose of preventing an adverse situation from occurring, in which the information recorded on the second recording layer 45 of the optical disk according to the present invention cannot be reproduced in a CD/DVD compatible player employing one light source of a shorter wavelength light, for example, a light of 650 nm wavelength.

To obtain the characteristics of the partially light-transmitting film 35 as described above, the partially light-transmitting film 35 is formed of dielectric materials as follows.

That is to say, the partially light-transmitting film 35 may be formed of dielectric materials such as silicon (Si), silicon nitrides (SiN_x), beryllium-copper alloys, titanium dioxide (TiO_2) or silicon dioxide (SiO_2). Here, the reflectance of the partially light-transmitting film 35 with respect to the first wavelength light and the transmittance thereof with respect to the second wavelength light can be determined by adjusting the thickness of the partially light-transmitting film 35.

In addition, the partially light-transmitting film 35 may be constructed in the form of dielectric multi-layers laminated in sequence with a titanium dioxide (TiO_2) layer, a magnesium fluoride (MgF_2) layer and a titanium dioxide (TiO_2) layer.

Further, the partially light-transmitting film 35 preferably includes dielectric layers of a high refractive index ranging from about 2.0 to 2.9 and dielectric layers of a low refractive index ranging from about 1.3 to 2.0.

When the dielectric layers of a high refractive index and the dielectric layers of a low refractive index are, in sequence from the side illuminated by light, laminated as described above, the reflectance (R) at the interface thereof is determined by the following equation

$$R=[\frac{n_2-n_1}{n_2+n_1}]^2\cos(\frac{4\pi d}{\lambda})$$

where n_1 and n_2 are refractive indices of the respective dielectric layers of a high refractive index and dielectric layers of a low refractive index, d is the

thickness of each dielectric layer of the high refractive index, and λ is the wavelength of incident light.

Accordingly, the reflectance of the partially light-transmitting film 35 with respect to the wavelength of light is appropriately determined by laminating the dielectric layers of the high refractive index and the dielectric layers of the low refractive index as shown in FIG. 4. Here, each layer of the dielectric layers of the high refractive index and the dielectric layers of the low refractive index may be made of a dielectric material such as silicon (Si), silicon nitrides (SiN_x), beryllium copper alloys, titanium dioxide (TiO_2) or silicon dioxide (SiO_2).

In addition, as shown in FIG. 5, the partially light-transmitting film 35 may comprise a first dielectric layer 35a of a high refractive index, a second dielectric layer 35b of a low refractive index, and a third dielectric layer 35c of a high refractive index which are laminated in sequence from the side of the first recording layer 33 (see FIG. 2). When each dielectric layer is formed of silicon nitride (SiN), and the refractive index of the dielectric layers 35a and 35c of the high refractive index is 2.88 and the refractive index of the dielectric layer 35b of the low refractive index is 1.94 as shown in FIG. 5, the characteristic reflectances of the partially light-transmitting film 35 with respect to light of the first wavelength of 650 nm and light of the second wavelength of 780 nm are shown in FIG. 6.

FIG. 6 is a graph which illustrates the variations in the reflectances of the first and second wavelengths with respect to thickness variations of the first dielectric layer 35a when the thickness of the second dielectric layer 35b is 900 Å and the thickness of the third

dielectric layer 35c is 600 Å. As shown in FIG. 6, in the vicinity of a thickness of 1500 Å, the reflectance of the light of the first wavelength of 650 nm is as high as about 57% and the reflectance of the light of the second wavelength of 780 nm is as low as about 16%, and therefore it is found that the partially light-transmitting film 35 of this example shows a characteristic wavelength selectivity to transmit about 84% of the light of the second wavelength. Accordingly, the reflectances of light beams of the first and second wavelengths can be selectively adjusted by adjusting the thickness or the refractive index of each layer of the partially light-transmitting film 35.

Now, the reproduction modes of the optical disk according to the present invention are explained when the information of the optical disk is reproduced respectively in ,for example, a compact disk player and a digital versatile disk player.

Referring to FIG. 7, when the optical disk is played in the digital versatile disk player, light 51 of a 650 nm wavelength emitted from a light source is converged by an objective lens 53 of having a numerical aperture of 0.6 and is focused on the first recording layer 33.

Referring to FIG. 8, on the other hand, when the optical disk is played in the compact disk player, light 61 of a 780 nm wavelength emitted from a light source is converged by an objective lens 63 of having a numerical aperture of 0.45. The converged light 62 is transmitted through the transparent substrate 31, the first recording layer 33, the partially light-transmitting film 35 and the spacing layer 39, and is focused on the second recording layer 45.

Consequently, the optical disk according to the present invention can be played compatibly in disk players of different format standards, for example, a compact disk player (CDP) or a digital versatile disk player (DVDP), by recording information on the first and second recording layers 33 and 45 and forming, between the two layers 33 and 45, the partially light-transmitting film 35 which exhibits different transmittances depending on the wavelength of light.

It is contemplated that numerous modifications may be made to an optical disk of the present invention without departing from the scope of the invention as defined in the following claims.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated

otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS

1. An optical disk for compatible reproduction by optical disk players of different format standards, comprising:

a transparent substrate for transmitting incident light;

a first recording layer having an information recording surface for recording an information signal, said information signal for reproduction by light of a first wavelength;

a partially light-transmitting film formed on a surface of the first recording layer, said film exhibiting different transmittances depending on the wavelength of incident light for reflecting most of the light of said first wavelength and transmitting most of the light of a second wavelength;

a spacing layer formed on a surface of said first recording layer for transmitting the light transmitted through said partially light-transmitting film;

a second recording layer having an information recording surface for recording an information signal said information signal for reproduction by the light of said second wavelength transmitted through the partially light-transmitting film; and

a reflective film formed on the information recording surface of the second recording layer for reflecting the light focused on the second recording layer.

2. The optical disk as claimed in claim 1, wherein the partially light-transmitting film comprises any one or a combination of materials selected from the group comprising silicon, silicon nitrides, beryllium copper alloys, titanium dioxide and silicon dioxide.

3. The optical disk as claimed in claim 1, wherein the partially light-transmitting film is a multilayered film laminated in sequence with a titanium dioxide layer, a magnesium fluoride layer, and a titanium dioxide (TiO_2) layer.

4. The optical disk as claimed in claim 1, 2 or 3, wherein the partially light-transmitting film includes a dielectric layer of a high refractive index within the range from about 2.0 to 2.9 and a dielectric layer of a low refractive index within the range from about 1.3 to 2.0.

5. The optical disk as claimed in claim 4, wherein each of the dielectric layer of the high refractive index and the dielectric layer of the low refractive index comprises one or a combination of materials selected from a group comprising silicon, silicon nitrides, beryllium-copper alloys, titanium dioxide and silicon dioxide.

6. The optical disk as claimed in claim 4, wherein the partially light-transmitting film includes a dielectric layer of a high refractive index, a dielectric layer of a low refractive index, and a dielectric layer of a high refractive index which are laminated in sequence from the side of the first recording layer.

7. The optical disk as claimed in any preceding claim, wherein the reflective film comprises any one or a

combination of materials selected from the group comprising aluminum, aluminum alloys, copper and copper alloys.

8. The optical disk as claimed in any preceding claim, wherein the track pitch of the first recording layer is about 0.74 μm, and the thickness between the transparent substrate and the information recording surface of the first recording layer is about 0.6 mm.

9. The optical disk as claimed in any preceding claim, wherein the track pitch of the second recording layer is about 1.6 μm and the thickness between the transparent substrate and the information recording surface of the second recording layer is about 1.2 mm.

10. An optical disk for compatible reproduction by optical disk players of different format standards, comprising:

a first recording layer for recording an information signal for reproduction by light of a first wavelength;

a second recording layer for recording an information signal for reproduction by light of a second wavelength; and

a partially light-transmitting film disposed between said first recording layer and said second recording layer for reflecting light of said wavelength and transmitting light of said second wavelength.

11. A method for forming a compact disk, comprising the steps of:

forming first and second recording layers for use with first and second wavelengths, respectively;

forming a partially light-transmitting film between said first and second recording layers for reflecting light of said first wavelength and transmitting light of said second wavelength.

12. An optical disk substantially as hereinbefore described with reference to Figures 2 to 8 of the accompanying drawings.

The Patent Office

18

Application No:	GB 9809623.3	**Examiner:**	Donal Grace
Claims searched:	1 to 12	**Date of search:**	26 August 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): G5R (RB21, RB24A)

Int Cl (Ed.6): G11B 7/007, 7/14, 7/24

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2017379 A	(PHILIPS)	1, 10, 11
X	EP 0762406 A1	(BALZERS)	1, 2, 10, 11
X	EP 0745985 A2	(AKIRA)	1, 2, 7-11
X	EP 0520619 A1	(PIONEER)	1, 2, 7, 10, 11
X	EP 0368442 A2	(PIONEER)	1-6, 10, 11
X,P	WO 98/00842 A1	(THOMSON)	1, 8-11
X	WO 97/14145 A1	(PHILIPS)	1, 2, 7, 10, 11
X	WO 97/09716 A1	(PHILIPS)	1, 10, 11

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☒ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: ______________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.